Vaccine 29S (2011) D74–D79

Contents lists available at SciVerse ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

The expanded programme on immunization: A lasting legacy of smallpox eradication

Jean-Marie Okwo-Bele*, Thomas Cherian

Department of Immunization, Vaccines and Biologicals, World Health Organization, Geneva, Switzerland

ARTICLE INFO

Article history:
Received 24 October 2011
Received in revised form 17 January 2012
Accepted 25 January 2012

Keywords:
Smallpox
Eradication
EPI

ABSTRACT

Since the mid-1970s, the widespread establishment and implementation of the Expanded Programme on Immunization (EPI) has led to remarkable achievements in controlling vaccine preventable diseases worldwide. Today, more children than ever are being reached with immunization; interruption of poliomyelitis transmission has occurred in most countries; mortality due to measles, tetanus, diphtheria and pertussis has been reduced to record low levels. In addition, increasing numbers of vaccines are being used for infants and older age persons, such as vaccines against hepatitis A and hepatitis B, *Haemophilus influenzae* type b, rotavirus, pneumococcus, meningococcus, human papilloma virus (HPV) and varicella.

The design of EPI reflects in large part the experience accumulated during the implementation of the intensified campaign for smallpox eradication during the period 1966–1977. At that time, the existing health infrastructure and network was found inadequate to reach most individuals with community wide immunization programmes in most countries. Thus, efforts were made to train dedicated health personnel and allocate specific resources for programme coordination and implementation. With the establishment of EPI, there was a gradual shift in emphasis from vaccination campaign strategies using mobile teams to the delivery of immunization services as part of routine health services of health facilities. Both the campaign and the outreach strategies are nevertheless required to reach those segments of the population not reached by the routine health services and to accelerate the achievement of disease control initiatives such as polio eradication and measles elimination.

Whilst the campaign for smallpox eradication was set up as special and time-limited effort, the EPI requires long-term sustainable approaches to protect new cohorts of susceptible persons with vaccination and monitor trends and progress towards disease control with high quality surveillance.

1. Introduction

In May 1974, the World Health Assembly (WHA) requested the World Health Organization (WHO) to establish EPI to provide universal access to a set of life-saving vaccines [1]. The immense success of the world-wide smallpox eradication programme, which was intensified from 1966 to 1977, provided the evidence that universal access with immunization was possible. This realization, together with the fact that vaccines against a number of life-threatening diseases existed but reached only a very small proportion of the populations in developing countries led to the decision to establish EPI.

Smallpox eradication benefited from dedicated financial and human resources, high level political and community support and adequate logistics systems. In many countries, smallpox teams undertook to provide other vaccines such as Bacille Calmette-Guerin (BCG), measles, yellow fever and diphtheria–tetanus–pertussis (DTP) vaccines [2]. These formed the basis for the strengthening of the broader immunization programmes in many countries.

The principles, lessons and benefits from the smallpox eradication campaign have been well documented and are referred to in the various articles contained in this supplement. Here, we focus on four of them that are relevant to EPI as a base for sustainable vaccine delivery as well as the adaptation of vaccination strategies to reach disease elimination and eradication: firstly, the definition of objectives and goals which is a key element in determining programme strategies and tactics; secondly, vaccine quality control to ensure the use of potent vaccines at all times; thirdly, the need for reliable supply systems to support field operations; and fourthly, ensuring that safe immunization practices are implemented in all

* Corresponding author at: Department of Immunization, Vaccines and Biologicals, World Health Organization, 20, Avenue Appia, 1211 Geneva 27, Switzerland. Tel.: +41 227912779.
E-mail address: okwobelej@who.int (J.-M. Okwo-Bele).

0264-410X/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.vaccine.2012.01.080

countries. We also discuss some of the remaining challenges and ways forward so that the benefits of vaccines and immunization are further expanded during the next decade of vaccines and beyond.

2. Major principles and lessons learned from smallpox eradication

2.1. Establishing objectives and goals

In 1966, the launch of the intensified smallpox eradication programme was marked with the setting of a clear ultimate objective of "nil incidence of smallpox". Making this objective explicit served to adjust programme strategies and tactics. The performance measurement shifted from measuring the numbers of vaccinations performed to improving methods for case detection and containment of outbreaks.

Setting measurable goals is a key element that stimulates commitment for planning and allocation of resources to meet the programme needs [3]. However, the pressure to meet some short-term disease control goals need to be balanced with efforts required to develop strong health systems for service delivery and programme monitoring [4].

The over-arching EPI goal is to reduce morbidity and mortality due to vaccine-preventable diseases. The EPI initial emphasis was to increase and measure immunization coverage against targeted diseases, using immunization coverage of infants with the third dose of diphtheria–tetanus–pertussis vaccine – DTP3 – as a key programme performance indicator. DTP3 coverage rose from 20% in 1980 to 75% in the 1990, following countries adoption of the WHA resolution on EPI and implementation of accelerated vaccination strategies in the context of the Universal Childhood Immunization (UCI) initiative launched by UNICEF in collaboration with WHO. Then, DTP3 coverage stagnated and even declined in some countries during the 1990s due to health system weaknesses, lack of political commitment and failure to allocate the resources required to sustain the gains made earlier. In the recent years, however, DTP3 coverage has increased, as countries allocated additional resources, supplemented in some instances with support from the GAVI Alliance. In 2010, the global DTP3 coverage is estimated at 85%, with 130 out of 194 WHO member states achieving ≥90% DTP3 coverage nationally, which is one of the immunization goals set in the Global Immunization Vision and Strategy adopted by the WHA in 2005 [5]. Table 1 presents the immunization coverage figures by vaccine and by WHO region for 2010. DTP3 coverage is lowest (77%) in the African and South East Asian Regions and higher (96%) in the Western Pacific and European Regions. DTP3 coverage was 93% in the American region and 87% in Eastern Mediterranean region [6] (http://www.who.int/immunization_monitoring/data/SlidesGlobalImmunization.pdf).

Table 1
Immunization coverage by vaccine and WHO region (weighted regional average) – worldwide, 2010.

	Vaccine coverage (%)					
	BCG	DTP3	Polio3	MCV1	HepB3	Hib3
Global	90	85	86	85	75	42
WHO region						
African	85	77	79	76	76	62
American	96	93	93	93	89	92
Eastern Mediterranean	88	87	87	85	84	58
European	94	96	96	95	78	75
Southeast Asian	89	77	77	79	52	9
Western Pacific	97	96	96	97	91	10

Source: WHO. Global routine vaccination coverage, 2010. Wkl Epidemiol Rec 2011;46(86):509–20.

2.1.1. Monitoring immunization programme performance

Since 1980, WHO and UNICEF have tracked the performance of national immunization programme performance by monitoring and publishing estimates of national immunization coverage. The annual estimates and time series are published each year and available at the WHO and UNICEF websites, respectively.[1]

Administrative data on the number of vaccinations provided during a given period of time form the basis of the estimates of immunization coverage. These data are collected in tally sheets at the immunization delivery point and reported to local authorities, and aggregated and reported to the higher administrative levels up to the national levels. Household surveys that collect data on immunization are the other major source of empiric data on immunization coverage. The three main household survey sources are the EPI cluster survey [7], the UNICEF Multiple Indicators Cluster Survey (MICS) [8], and the Demographic and Health Survey (DHS) [9]. The EPI cluster surveys are designed specifically to measure immunization coverage, are simple to perform and are usually conducted by the national immunization programme staff. The MICS and DHS surveys collect data on a number of health indicators. They have a more rigorous design, and are, therefore, more expensive and logistically more difficult. Each of these sources have their advantages and disadvantages. Administrative data are available in a timely fashion allowing timely corrective actions at all administrative levels in the health system, but are subject to numerator (number of children vaccinated) and denominator (size of the target population) biases. Household surveys allow estimation of the immunization coverage even if the size of the target population is not known, but they do not allow for timely corrective action, may have wide confidence intervals, are affected by the quality of the interviews, and rarely provide estimates at district and lower administrative levels. The WHO and UNICEF estimates of national immunization coverage are based on a careful review of the different sources of data and derivation of estimates after due consideration of the various biases and on local expert opinion [10]. More recently a formal knowledge representation and reasoning (KRR) system has been instituted to ensure that the WHO–UNICEF estimates are documented, replicable, consistent, and transparent (Burton A, personal communication).

A number of measures are being taken to improve the quality of the administrative coverage data. The use of immunization registries is being explored in a few low and middle income countries. Guidelines are also being developed for assessing and improving the estimates of the target population for immunization.

Recent outbreaks of vaccine preventable diseases in populations with high estimated vaccine coverage have highlighted the limitations of immunization coverage and the need for greater attention for disease surveillance. Serological surveys in some of these populations have demonstrated immunity gaps to vaccine preventable diseases and renewed interest in the use of biomarkers as an additional source of data to validate immunization programme performance.

2.1.2. Disease surveillance

Disease surveillance standards and systems are critical elements of today's EPI. Effective surveillance systems provide information needed to monitor the trends in disease burden and the impact of disease control programmes, in addition to data needed to guide programme planning, priority setting, and mobilization and allocation of resources. This was recognized by the World Health Assembly when it recommended that Member States develop or

[1] http://www.who.int/immunization monitoring/en/globalsummary/wucoveragecountrylist.cfm and http://www.childinfo.org/immunization_countryreports.html.

maintain immunization and surveillance programmes (WHA 27.57, May 1974).

From 1974, the smallpox eradication campaign established standards for surveillance and case containment, which helped to accelerate the interruption of smallpox transmission. However, following small-pox eradication, many Member States failed to sustain the gains from the fever and rash surveillance established to monitor small-pox eradication to expand surveillance to include the other vaccine preventable diseases. Surveillance was re-established by the Polio Eradication Initiative, which has now developed into a high performing surveillance system, which enables rapid detection of polio cases throughout the world, including in low income countries, where the extensive polio surveillance systems with people, transport, laboratory network and data management facilities have been expanded to include surveillance of other vaccine-preventable diseases, including measles, rubella, and yellow fever.

Recognizing the need to revitalize surveillance as an essential component of immunization programme monitoring, the Global Framework for Immunization Monitoring and Surveillance (GFIMS) was published as a companion document to the Global Immunization Vision and Strategy (GIVS) [11,12].

The recently licensed vaccines to combat diseases such as *Haemophilus influenzae type b* (Hib), meningococcal disease, pneumococcal disease and rotavirus diarrhoea offer the potential to reduce further childhood morbidity and mortality. Surveillance data are critical to guide the decision-making process for vaccine adoption and introduction in the national immunization programmes and for impact monitoring. Several countries have set up networks of sentinel sites to conduct surveillance for rotavirus diarrhoea and invasive bacterial diseases. These systems need to be expanded and sustained, with careful attention to surveillance quality so that the data they generate are of sufficient quality to guide immunization policy and monitor disease control.

2.1.3. Accelerated disease control initiatives

As immunization coverage reached high levels, and based on the success of smallpox eradication, specific disease control objectives were added to EPI through global and regional resolutions of the WHO governing bodies, such as the resolution for world-wide eradication of poliomyelitis adopted by the WHA in May 1988.

To implement these resolutions, accelerated vaccination strategies in the form of mass vaccination campaigns are being implemented to complement routine immunization to rapidly reduce immunity gaps and interrupt disease transmission.

2.1.3.1. Measles and rubella control. In 1994, based on the success of small pox eradication and polio control, and on the success in a few pioneering countries in the region in markedly reducing measles incidence, the Pan American Sanitary conference resolved to establish the regional goal of elimination of measles by the year 2000 (resolution CSP24, R16, September 1994). The strategy to achieve this goal was based on a "catch up" campaign in children 1–14 years of age, sustain high routine coverage ($\geq$95%) in infants 12 months of age ("keep up"), and "follow up" campaigns in children 1–4 years of age with measles containing vaccines [13]. These vaccination campaigns were accompanied by case-based surveillance with laboratory confirmation. From 1998, measles vaccine was used in combination with rubella vaccine with the aim of using the same strategy to also eliminate congenital rubella. As a result, endemic transmission of measles was eliminated from the region of the Americas in 2002 [14].

Despite the success with measles control in the region of the Americas, measles remained a major cause of child mortality globally, particularly in countries in Africa and Asia. In 2000, the World Health Assembly adopted a resolution to reduce global measles deaths by half over the period 2000–2005, compared with 1999 levels. This goal was achieved by increasing coverage with the routine dose of measles vaccination, and the provision of a second opportunity for vaccination through supplementary immunization activities (SIAs), packaged with vitamin A supplementation, deworming medicine, insecticide treating nets and polio vaccine, in the 47 highest burden countries [15]. The WHO African region achieved the largest total reduction, contributing 72% of the global reduction in measles mortality. The support of the Measles Initiative Partnership played a critical role in supporting African countries in their efforts to reduce measles mortality. Building on this achievement, a second, more ambitious goal was established in 2006 to reduce estimated measles mortality by 90% by 2010 compared with estimated 2000 levels. By 2008, it was estimated that 78% reduction in measles deaths had been achieved. All WHO regions, except the WHO South-East Asia region (SEAR), were estimated to have achieved 90% measles mortality reduction [16]. In 2011, India initiated a two-dose measles vaccination strategy through routine immunization services and/or SIAs, putting SEAR on track to achieve the measles mortality reduction goal. Whilst measles elimination has been achieved in the WHO Region of the Americas, the European, Eastern Mediterranean, and Western Pacific have established targets to eliminate measles by 2015 or earlier, the African region adopted the goal to eliminate measles by 2020 and the South-East Asian region passed a resolution urging countries to mobilize resources to support elimination of measles. In 2010 the World Health Assembly endorsed the view that measles can and should be eradicated and established interim goals in preparation for establishing a target date for eradication. Achieving these interim goals will nevertheless require additional and dedicated resources to improve measles routine coverage in all districts, implement quality mass campaigns to provide a 2nd opportunity of measles vaccination, nation-wide case-based surveillance and aggressive outbreak control activities.

2.1.3.2. Maternal and neonatal tetanus elimination. The use of maternal immunization with tetanus toxoid to prevent neonatal tetanus was included in EPI a few years after its inception. However, in the 1980s coverage of pregnant women with two doses of tetanus toxoid remained low. In 1989 the World Health Assembly passed a resolution calling for elimination of maternal and neonatal immunization (elimination being defined as less than one case of neonatal tetanus per 1000 live births in every district). By 1992 a 25% reduction in deaths due to neonatal tetanus was achieved, however neonatal tetanus activities continued to miss high risk populations with low access to health services. In order to overcome these shortcomings, high-risk populations were targeted for mass vaccination campaigns targeting all women in the child-bearing age (usually 15–45 years) with three doses of tetanus toxoid. When conducted successfully this approach can result in a rapid reduction in neonatal tetanus [17]. By 2011 neonatal tetanus has been validated to have been eliminated in 21 countries high risk countries as well as several states or provinces in India, Indonesia and Ethiopia, leaving 38 countries still to eliminate maternal and neonatal tetanus, mainly in Africa and Asia.

2.1.3.3. Epidemic meningitis in Sub-Saharan Africa. Epidemic meningitis has been reported to occur over the past century mainly in the "African Meningitis Belt" that comprises 25 contiguous countries from Senegal in the West to Ethiopia in the East. Large epidemics tend to occur every 7–12 years, affecting populations in remote underserved areas and causing high case fatality rates and permanent disabilities [18,19].

In 2001, with funding from the Bill & Melinda Gates Foundation, WHO and PATH established the Meningitis Vaccine Project, to develop a new, affordable conjugate vaccine against Group A

meningococcus, the most common cause of African meningitis epidemics. Licensed in 2009, the new vaccine offers a greater and more sustained immune response against Group A meningococcus than is seen with polysaccharide vaccines, is safe and efficacious amongst very young children who do not respond to conventional polysaccharide vaccines and provides herd immunity [20,21].

Shortly after its licensure, the new vaccine was introduced through mass vaccination campaigns in three hyperendemic countries (Burkina Faso, Mali, and Niger) of West Africa and will be further rolled out in 10 meningitis belt countries by 2012. The vaccination campaigns are aimed to achieve high coverage amongst populations 1–29 years of age and are expected to eliminate epidemics of meningococcal meningitis in the region.

Available surveillance data are already demonstrating a drastic reduction in confirmed meningitis A cases compared with the pre-vaccine introduction period. Studies on dose ranging and schedule evaluation for children <1 year continue with results expected by 2013, so that policy recommendations can be issued for vaccinating new infant cohorts not covered by the on-going campaigns [22].

2.2. Vaccine quality control

In 1967, less than 10% of smallpox vaccines used in endemic countries were found to meet the smallpox vaccine requirements of potency and heat stability. In order to reduce the risk of the supply and use of substandard vaccines, WHO established a smallpox vaccine quality control programme with independent testing centres and technical advice to producing manufacturers.

This work continued and further expanded with the establishment of EPI. Today, continuous vaccine quality assurance involves several players. First, the WHO's Expert Committee on Biological Standardization (ECBS) was established for setting international standards of vaccine efficacy, safety and quality. The ECBS proposes detailed recommendations and guidelines for the manufacturing, licensing and control of vaccines and other biological products and also develops reference preparations that are used as reference materials by manufacturers and regulatory authorities to calibrate regional, national or in-house working materials [23].

In addition, WHO also prequalifies vaccines for procurement by U.N. agencies, by independently assessing the quality of the vaccine to ensure that it meets established standards. One of the prerequisites for WHO pre-qualification is that the national regulatory authority (NRA) of the country of manufacture of the vaccine is fully functional. Assessment of functionality, which consists of assessment against a set of six functions (market authorization and licensing, lot release, laboratory access, post-marketing surveillance including adverse events following immunization surveillance, regular inspections, and authorization/approval of clinical trials).[2]

With an increasing number of vaccines, including the newer vaccines, being manufactured in emerging economies, WHO has supported the NRAs of these countries to meet the established criteria for full functionality.

2.3. Logistics: cold chain and vaccine management

Vaccine management and cold chain are the backbone of immunization programme. The required storage temperature for most vaccines remains set at 2–8 °C, given the thermolability of some vaccines (e.g. Oral Polio Vaccine, Rotavirus vaccine) and the sensitivity to freezing of adjuvanted vaccines (e.g. DPT containing vaccines). The increased number and cost of vaccines used in the national immunization programmes, combined with the need to expand further immunization coverage require additional investments to improve the EPI supply chain and logistics. One stream of efforts is directed to improve product design, so that for example vaccines can be stored at higher temperatures or packaged to minimize storage space requirements. At the same time, the supply chains should be further strengthened for greater efficiency with improved management capacity to cope with the increased complexity and workload.

2.4. Safety of immunization

The safety of injection practices has received due attention in EPI, following observations in many countries of inadequate and harmful practices with sterilizable equipment as well as disposable syringes and needles. To address this huge challenge, WHO and UNICEF and their partners decided that auto-disable syringes should be the only injection materials supplied by UNICEF and all purchases of vaccine should include sufficient AD syringes and safety boxes bundled with the vaccine. Specific funding allocations by the GAVI Alliance have facilitated the implementation of this policy.

With an increasing number of vaccines being manufactured in developing countries and a number of new vaccines with limited data on safety being introduced into the national immunization programmes of developing countries, it is essential that capacity to detect and respond to adverse events following immunization (AEFI) be established in developing countries. In 2011, WHO launched the Vaccine Safety Blueprint, that aims to draw attention to the need for enhanced vaccine pharmacovigilance globally, and sets out a framework for coordinated action that will raise the level and accuracy of vaccine safety monitoring globally that will enable cases of AEFI to be investigated wherever they occur. The blueprint proposes strategies to strengthen vaccine pharmacovigilance in low- and middle-income countries with three levels of implementation: (1) minimal capacity in all low- and middle-income countries; (2) enhanced capacity in those countries where new vaccines are being introduced; and (3) and international support structure that leverages existing infrastructure and expertise for the benefit of the global community.

3. Remaining challenges and ways forward

Despite the extraordinary progress made towards reducing vaccine-preventable diseases, the immunization agenda remains largely unfinished. Whilst the estimated number of all deaths in children under five in 2008 was 8.8 million, nearly 20% of all deaths in children under 5 are vaccine preventable [24]. The total number of children who died from diseases preventable by vaccines currently recommended by WHO is approximately 1.7 million.[3] For 2010, it is estimated that 19.3 million children had not been completely vaccinated and remained at risk for vaccine-preventable causes of morbidity and mortality.[3] Measles outbreaks were observed in Africa in 2010 and in 2011, as a result of persisting pockets of unvaccinated children. In 2011, 2500 measles deaths were reported in the WHO African region; because of low reporting sensitivity, this figure is assumed to be an under-estimate (B Masresha personal communication).

Meanwhile, EPI continues to evolve. Historically vaccinations have targeted the children under one year of age. It is recognized that vaccinations of other age groups throughout the course of life are critical, both to boost the effects of the infant doses and to

[2] http://www.who.int/immunization_standards/national_regulatory_authorities/strengthening/en/index.html/.

[3] http://www.who.int/immunization_monitoring/Global_Immunization_Data.pdf.

deliver primary vaccinations. In addition, many vaccines are beneficial to school children, adolescents, adults, the aged and to workers in specific professions (e.g. health workers) calling for the expansion of vaccination services to all age groups.

The next decade of vaccines will undoubtedly provide an unprecedented opportunity to protect more people against more diseases [25]. Therefore countries should continue to build the capacity to determine which vaccinations are appropriate, in which schedule, for which population in order to cover all those at risk, and from which sources additional resources requirements will be obtained. For many developing countries, technical and financial assistance will be required to support policy formulation, access to vaccines and programme implementation.

3.1. Structure and processes for developing immunization policy and strategies

With the increasing array of new vaccines, which are all more expensive than the traditional vaccines, a number of tools have been developed to assist countries in formulating their national policies and strategies that take into account national health priorities and capacities.

The vaccine position papers published by WHO contained summaries of information about licensed vaccines of public health interest and provide WHO recommendations on vaccine use. These position papers are produced through the policy advice provided by the Strategic Advisory Group of Experts on immunization (SAGE) [23]. The process for preparing papers has been continuously improved over time. The latest addition is the inclusion of tables that assess and grade the quality of the evidence, using the GRADE approach [26].

Prioritizing amongst multiple "recommended" vaccines – is increasingly common in low- and middle-income countries and falls squarely on the countries themselves, who are best positioned to assess the local epidemiological, programmatic, and financial impacts of the decisions. The Pan American Health Organization (PAHO) has developed the "ProVac Initiative", as a package of tools for generation of country specific evidence (cost-effectiveness and epidemiological and economic impact of vaccines) and for strengthening national decision-making processes such as the national immunization technical advisory group. These tools have facilitated the adoption of new vaccines (e.g., rotavirus, HPV and pneumococcal vaccines) in the countries in the region and elsewhere [27]. Efforts and resources will be needed to evaluate, update and refine these tools.

3.2. Initiatives to accelerate access to new vaccines

The annual expenditure on immunization for low-income countries is estimated to increase from an average figure per live birth of US$ 6.00 in 2000 to US$ 25.00 in 2008 and is likely to increase further to US$ 58.00 in order to accommodate pneumococcal conjugate and rotavirus vaccines. In order for such immunization programmes to be sustainable, greater efforts will be required to reduce vaccine prices to affordable levels and to promote greater investment in immunization programmes, by both the countries themselves and their development partners.

The GAVI Alliance, established in 1999, as a partnership of public and private organizations offers to eligible low income countries support for vaccines and immunization but also for health systems strengthening. Initially, the Alliance focused on the vaccines against hepatitis B and Hib, as well as yellow fever. In recent years, support included the new meningitis A conjugate, rotavirus and pneumococcal vaccines and from 2012, countries will apply for funding to introduce vaccines against HPV and rubella. Through a successful pledging conference held in June 2011, the GAVI Alliance attracted support to meet the projected demand of vaccines and cash-based programmes at least till 2015. In addition to traditional aid funds, the GAVI Alliance is supported by other financing instruments such as the International Financing Facility for Immunization (IFFIm) – a funding mechanism which converts long-term government commitments into immediately available cash resources by issuing bonds on the capital markets –, the Advanced Market Commitment (AMC) – a pull mechanism with an important role in shaping vaccine market shaping – and matching funds initiatives – to attract funds from private and foundation partners. Available data from WHO show that since 2000, the GAVI Alliance has helped countries prevent more than 5.5 million future deaths. The Alliance support is also credited with improving injection safety and routine immunization coverage but questions have been raised concerning the effectiveness of its health system strengthening delivery model.[4]

In 1979, the Pan American Health Organization (PAHO) established a revolving fund as a mechanism that ensures continuous access and supply of quality vaccines in the participating countries. The pooled fund has been able to secure affordable vaccine prices. As a result, the majority of countries in the Americas are today almost entirely self-sufficient in the financing of vaccines, including new vaccines, with over 90% of immunization costs paid for out of national government resources. In 2010, the Revolving Fund offered 45 different biologicals, with purchases totalling US$ 510 million.[5] Establishment of pooled procurement mechanisms is being explored in other regions to ensure access to new vaccines in the middle-income countries that are above the GAVI Alliance eligibility threshold.

3.3. Implementing EPI as an integral part of health systems

Whilst several new vaccines are being adopted to further reduce mortality and morbidity, they address some but not all the pathogens of the major causes of morbidity and mortality, such as pneumonia, diarrhoea and cervical cancer, suggesting the need to plan and implement comprehensive and integrated disease prevention and control strategies. The Global Action plan for the prevention and control of pneumonia is one example that sets out specific goals, targets and strategies to scale up key interventions of proven benefits such as exclusive breastfeeding, vaccination and treatment of pneumonia and outlines the priority actions that are required at various levels to ensure progress.[6]

4. Conclusions

During the past four decades, the world achieved unprecedented gains with the use of vaccines in saving lives, building from the lessons and experience of the smallpox eradication programme, including strong political commitment at global level, national leadership and coordination, effective programme management, vaccine quality control, performance monitoring and innovation.

Despite the challenges of limited health system capacity and competing priorities in several low income countries, today, immunization services are reaching an unprecedented number of persons, with more life-saving vaccines. Many partners are contributing additional resources, even more resources will be needed to realize the full potential of existing and new vaccines in the next decades.

The inability to build on the surveillance systems developed for documenting smallpox eradication was one of the failures of EPI and one that needs to be corrected. Surveillance for vaccine

[4] http://www.gavialliance.org/.
[5] http://new.paho.org/.
[6] http://whqlibdoc.who.int/hq/2009/WHO_FCH_CAH_NCH_09.04_eng.pdf.

preventable diseases which has been initiated for monitoring polio eradication and measles control need to be sustained and further enhanced to serve as a corner stone for all communicable disease surveillance.

With an increasing array of life-saving vaccines becoming available, immunization systems need to be strengthened to fully exploit the potential of immunization. Political commitment is critical to support the systemic changes required, including: (1) functional policy-making and regulatory bodies at the national level; (2) a fully trained and motivated work force established to manage and implement the programme; (3) robust supply chains to ensure that the right quantity of vaccines are available at the right place and time; and (4) appropriate operational research, to inform future immunization policies and practices and to overcome obstacles and bottlenecks to achieving universal coverage with immunization.

Conflict of interest

None.

References

[1] Keja K, Chan C, Hayden G, Henderson RH. Expanded programme on immunization. World Health Stat Quart 1988;41(2):59–63.
[2] Fenner F, Henderson DA, Arita I, Jezek Z, Ladnyi ID. Smallpox and its eradication. World Health Organization; 1988.
[3] Brestlow L. RulesSetting objectives for public health. Am Rev Public Health 1987;8(289):307.
[4] Levine OS, Bloom DE, Cherian T, de Quadros C, Sow S, Wecker J, et al. The future of immunisation policy, implementation, and financing. Lancet 2011;378(9789):439–48.
[5] Bilous J, Eggers R, Gasse F, Jarrett S, Lydon P, Magan A, et al. A new global immunisation vision and strategy. Lancet 2006;367(9521):1464–6.
[6] World Health Organization. Global routine vaccination coverage, 2010. Weekly Epidemiologic Rec 2011;86(46):509–20.
[7] Henderson RH, Sundaresan T. Cluster sampling to assess immunization coverage: a review of experience with a simplified sampling method. Bull World Health Organ 1982;60(2):253–60.
[8] United Nations Children's Fund. Multiple indicator cluster surveys (MICS). http://www.childinfo.org/mics.html [accessed 15.01.12].
[9] Measure DHS. Demographic and health surveys. http://www.measuredhs.com/What-We-Do/Survey-Types/DHS.cfm [accessed 15.01.12].
[10] Burton A, Monasch R, Lautenbach B, Gacic-Dobo M, Neill M, Karimov R, et al. WHO and UNICEF estimates of national infant immunization coverage: methods and processes. Bull World Health Organ 2009;87(7):535–41.
[11] Dabbagh A, Eggers R, Cochi S, Dietz V, Strebel P, Cherian T. A new global framework for immunization monitoring and surveillance. Bull World Health Organ 2007;85(12):904–5.
[12] Global framework for immunization monitoring and surveillance. World Health Organization; 2006.
[13] de Quadros CA, Olive JM, Hersh BS, Strassburg MA, Henderson DA, Brandling-Bennett D, et al. Measles elimination in the Americas. Evolving strategies. JAMA 1996;275(3):224–9.
[14] Centers for Disease Control and Prevention. Progress toward measles elimination – region of the Americas, 2002–2003. MMWR 2004;53(14):304–6.
[15] Wolfson LJ, Strebel PM, Gacic-Dobo M, Hoekstra EJ, McFarland JW, Hersh BS. Has the 2005 measles mortality reduction goal been achieved? A natural history modelling study. Lancet 2007;369(9557):191–200.
[16] van den Ent MM, Brown DW, Hoekstra EJ, Christie A, Cochi SL. Measles mortality reduction contributes substantially to reduction of all cause mortality among children less than five years of age, 1990–2008. J Infect Dis 2011;204(Suppl. 1):S18–23.
[17] Roper MH, Vandelaer JH, Gasse FL. Maternal and neonatal tetanus. Lancet 2007;370(9603):1947–59.
[18] Greenwood B. Manson Lecture. Meningococcal meningitis in Africa. Trans R Soc Trop Med Hyg 1999;93(4):341–53.
[19] World Health Organization. Control of epidemic meningococccal disease: WHO practical guidelines. Second edition; 1998.
[20] LaForce FM, Konde K, Viviani S, Preziosi MP. The meningitis vaccine project. Vaccine 2007;25(Suppl. 1):A97–100.
[21] LaForce FM, Okwo-Bele JM. Eliminating epidemic Group A meningococcal meningitis in Africa through a new vaccine. Health Aff (Millwood) 2011;30(6):1049–57.
[22] World Health Organization. Meeting of the Strategic Advisory Group of Experts on immunization, April 2011 – conclusions and recommendations. Weekly Epidemiolog Rec 2011;86(21):205–20.
[23] Duclos P, Okwo-Bele JM, Salisbury D. Establishing global policy recommendations: the role of the Strategic Advisory Group of Experts on immunization. Expert Rev Vaccines 2011;10(2):163–73.
[24] Black RE, Cousens S, Johnson HL, Lawn JE, Rudan I, Bassani DG, et al. Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet 2010;375(9730):1969–87.
[25] Horton R, Das P. The vaccine paradox. Lancet 2011;378(9788):296–8.
[26] Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 2008;336(7650):924–6.
[27] Andrus JK, Toscano CM, Lewis M, Oliveira L, Ropera AM, Davila M, et al. A model for enhancing evidence-based capacity to make informed policy decisions on the introduction of new vaccines in the Americas: PAHO's ProVac initiative. Public Health Rep 2007;122(6):811–6.